Sentinel-2 Data Quality Activities Status

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Sentinel-2 Data Quality Manager

14 January 2016
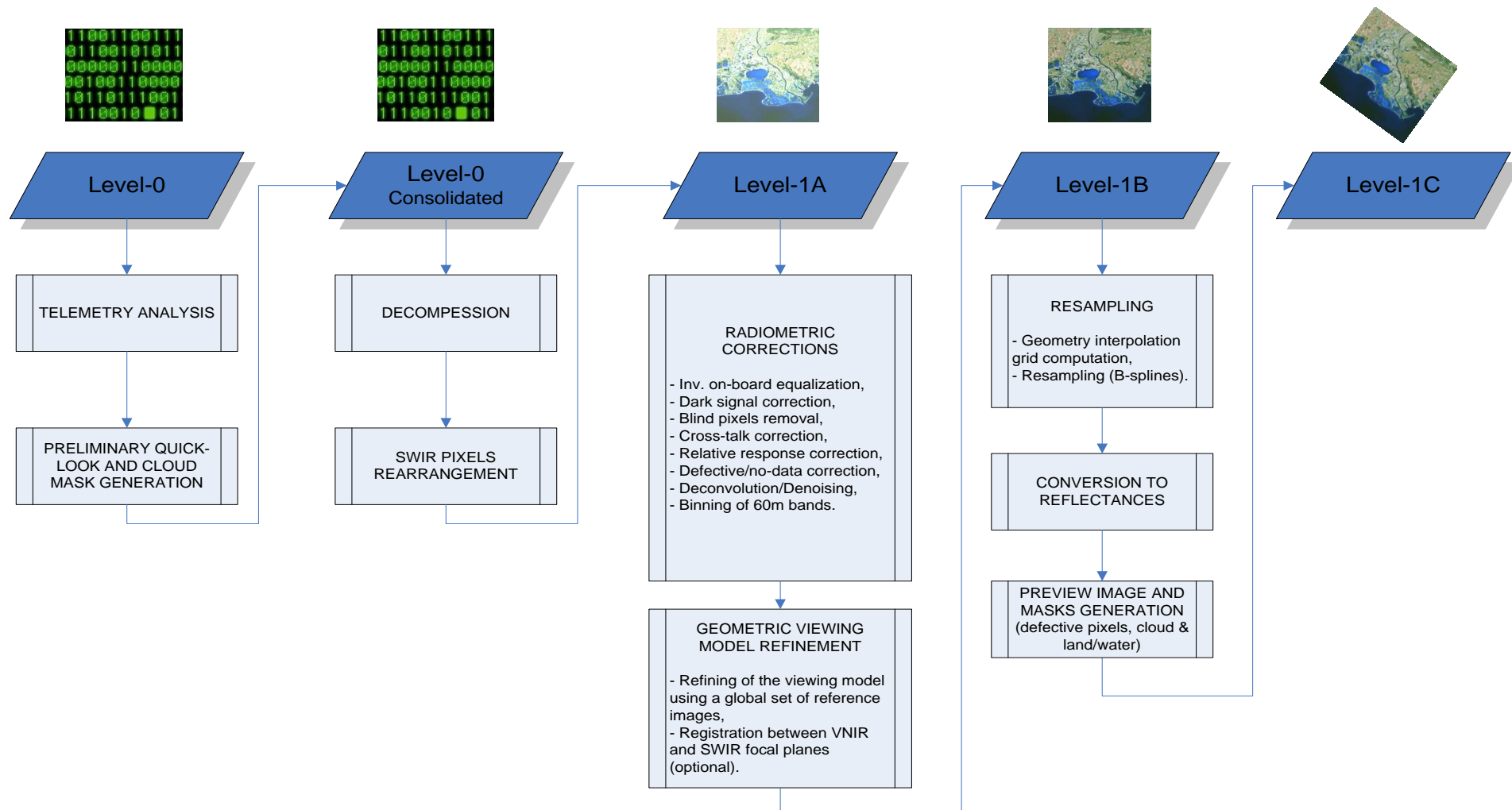
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Sentinel-2 Products

Name	High-level Description	Production	Preservation Strategy	Volume
Level-1B	Top-of-atmophere radiances in sensor geometry	Systematic	Long-term	~27 MB (each 25x23km^2)
Level-1C	Top-of-atmosphere reflectances in cartographic geometry	Systematic	Long-term	~500 MB (each 100x100km^2)
Level-2A	Bottom-of-atmosphere reflectances in cartographic geometry (prototype product)	On user side* (using Sentinel-2 Toolbox**)	N/A	~600 MB (each 100x100km^2)

*: The possibility of a systematic global production of L2A is currently being explored.
**: https://sentinel.esa.int/web/sentinel/toolboxes/sentinel-2
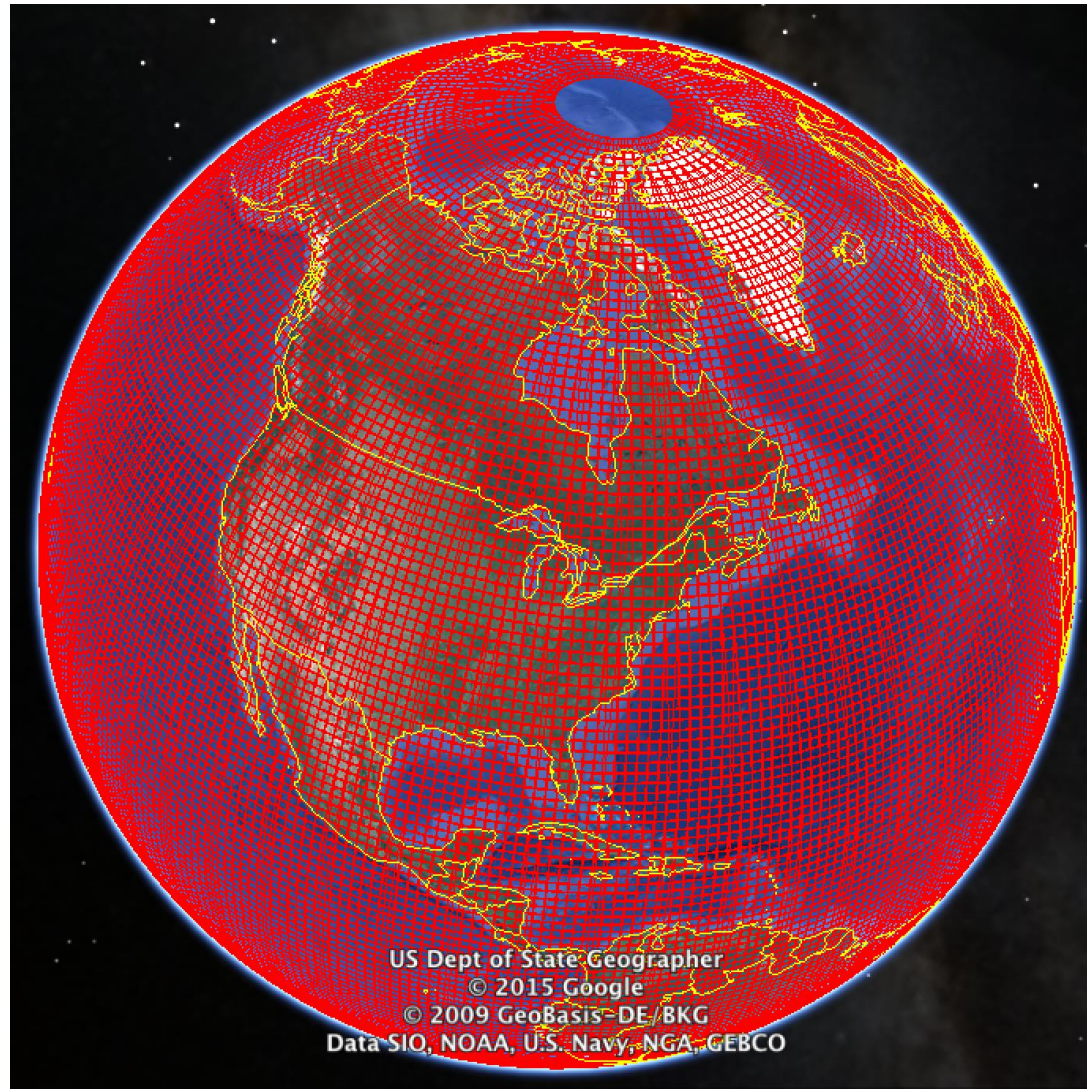
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Level-1C / Definition

- Top-of-atmosphere (TOA) reflectances in cartographic geometry

- Radiometry:
  - ✓ Reflectances coded in 12 bits.
  - ✓ Product includes all necessary parameters required to convert the provided reflectances into radiances.

- Geometry:
  - ✓ Projection UTM / WGS84.
  - ✓ Orthorectification uses an 90m-resolution DEM (PlanetDEM).
    http://www.planetobserver.com/products/planetdem/planetdem-90/
  - ✓ Sub-pixel multi-temporal registration between images.

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Level-1C / Algorithm

Level-0

Level-0 Consolidated

Level-1A

Level-1B

Level-1C

TELEMETRY ANALYSIS

DECOMPESSION

RADIOMETRIC CORRECTIONS - Inv. on-board equalization, - Dark signal correction, - Blind pixels removal, - Cross-talk correction, - Relative response correction, - Defective/no-data correction, - Deconvolution/Denoising, - Binning of 60m bands.

RESAMPLING - Geometry interpolation grid computation, - Resampling (B-splines).

PRELIMINARY QUICK-LOOK AND CLOUD MASK GENERATION

SWIR PIXELS REARRANGEMENT

CONVERSION TO REFLECTANCES

PREVIEW IMAGE AND MASKS GENERATION (defective pixels, cloud & land/water)

GEOMETRIC VIEWING MODEL REFINEMENT - Refining of the viewing model using a global set of reference images, - Registration between VNIR and SWIR focal planes (optional).

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Tiling grid KML file available on-line at sentinels.copernicus.eu

Operational Products Qualification

Level-1 Products preliminary qualification for initial distribution

MPC qualified for cal/val operations

Level-1 Products qualified (without geometric refinement)

Level-1 Products qualified (with geometric refinement)

Level-2A Prototype Product Validated

Phase-E1

Phase-E2

Launch   IOCR   IOCR+4m   IOCR+7m
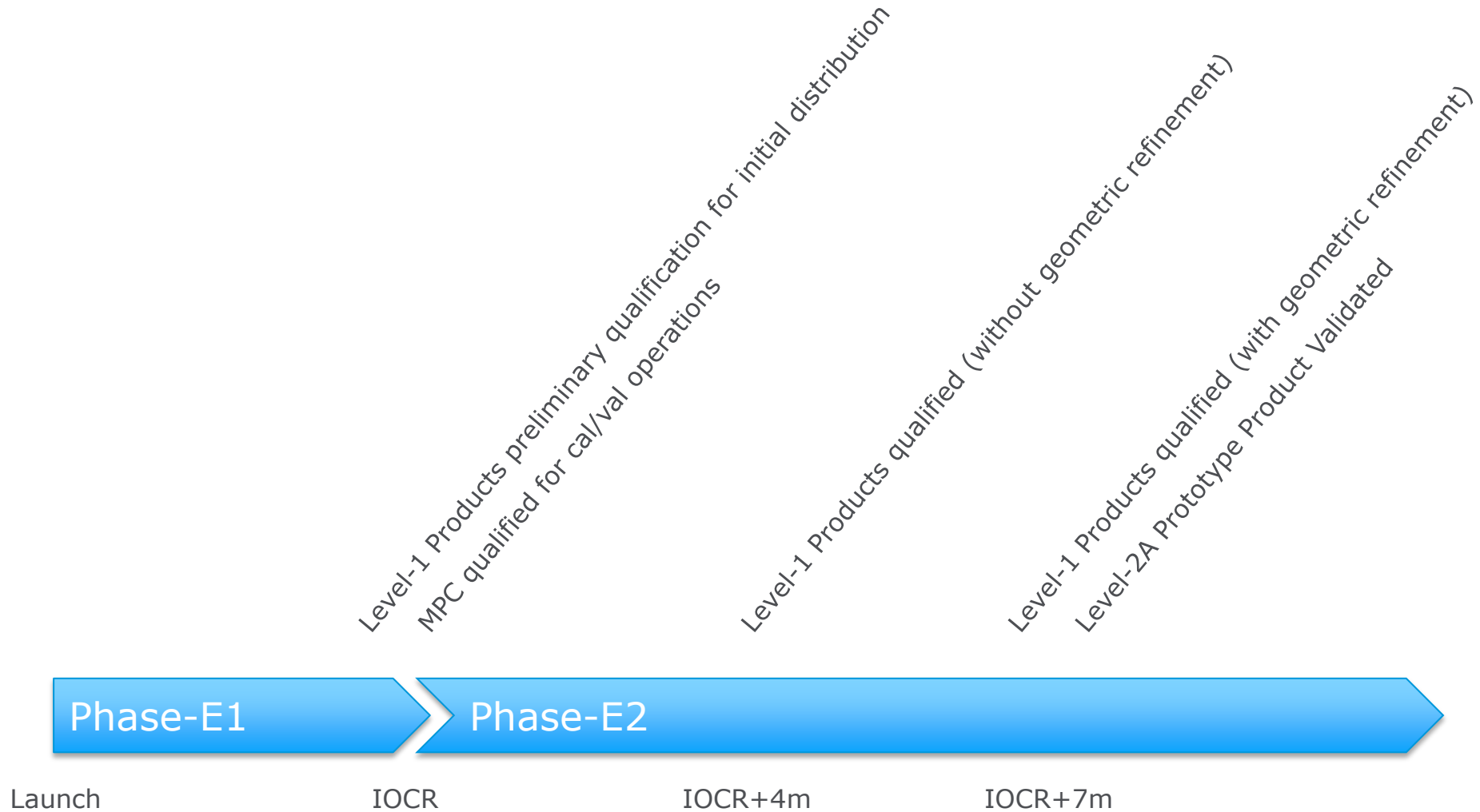
Products Qualification On-going

Requirement	Description	Measured performance
Absolute geolocation (without ground control points)	The geo-location uncertainty shall be better than 20 m at 2σ confidence level (without Ground Control Points).	< 10 m at 2σ ✔
Multi-spectral registration	The inter-channel spatial co-registration of any two spectral bands shall be better than 0.30 of the coarser achieved spatial sampling distance of these two bands at 3σ confidence level.	< 0.23 m at 3σ ✔
Absolute radiometric uncertainty	The absolute radiometric uncertainty shall be better than 5 % (goal 3%) for the set of bands specified in [SSRD] over the reduced dynamic range.	B1, B2, B3, B4: < 2% ± 2% WORK IN PROGRESS ✔
SNR	The Signal-to-Noise Ratio (SNR) shall be higher than the values specified in [SSRD].	All bands compliant with > 20% margin ✔

data quality report on-line
at https://sentinels.copernicus.eu/documents/247904/685211/Sentinel-2+Data+Quality+Report
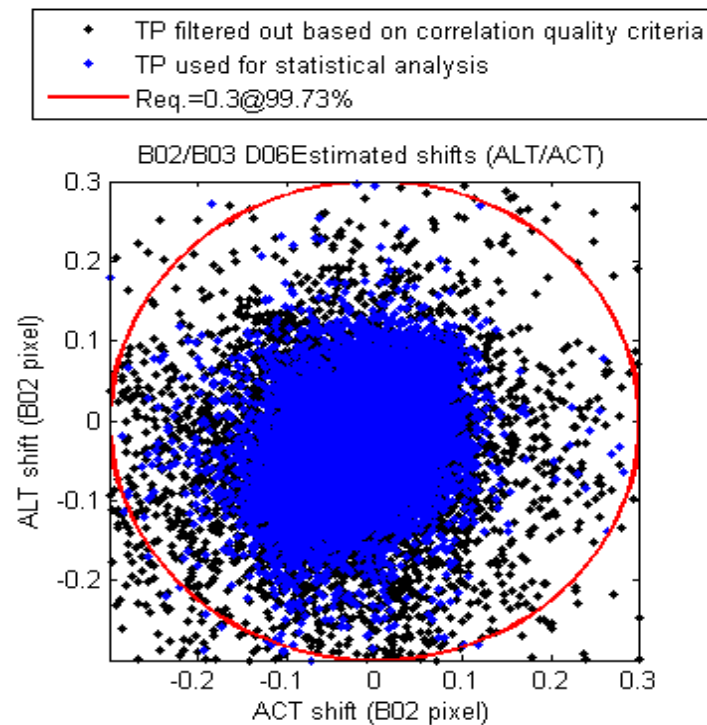
Level-1 Products Pre-Qualification

- ✓ Absolute geolocation performances (without geometric refinement) measured over 17 test sites.
- ✓ Measurements in line with requirements.

Image localisation performance evaluation B4 (B03)

Estimated Geolocation error at GCPs on band B04 (shifts x356)
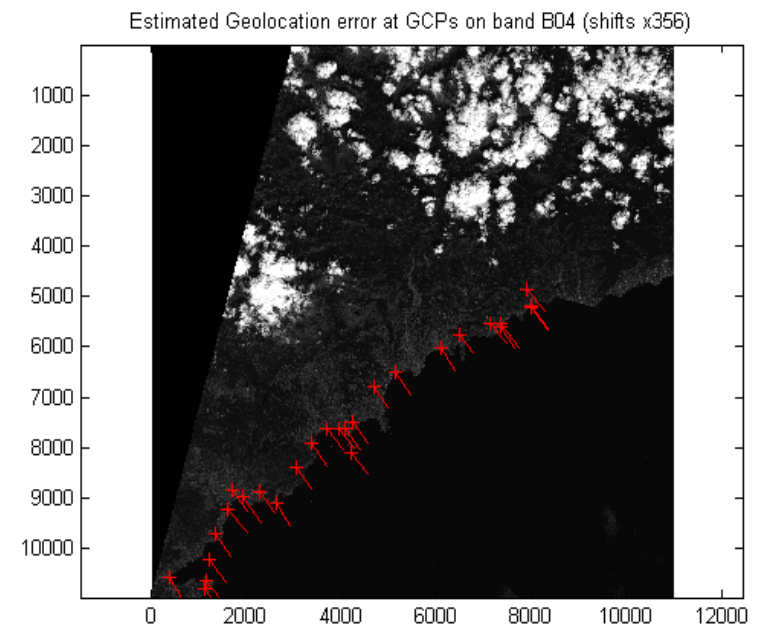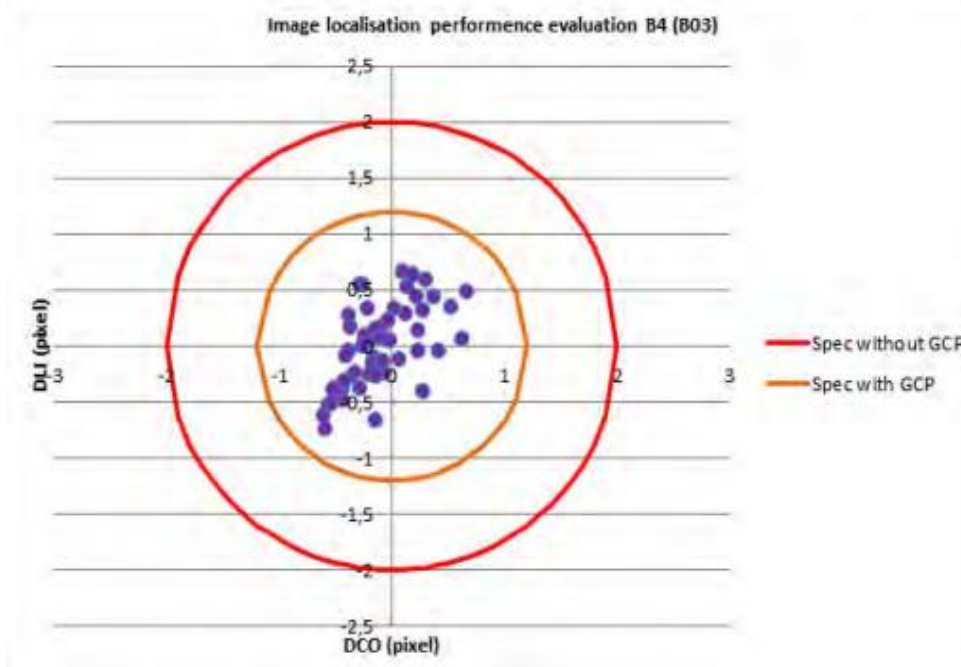
Level-1 Products Pre-Qualification

✓ Multi-spectral registration performances measured show that the mean circular error over all band couples and detectors is lower than 0.23 pixel of the coarser band.

Level-1 Products Pre-Qualification

✓ Signal-to-Noise Ratio (SNR) calculated from images of the MSI sun diffuser.

✓ Measured SNR values largely exceeding requirements.

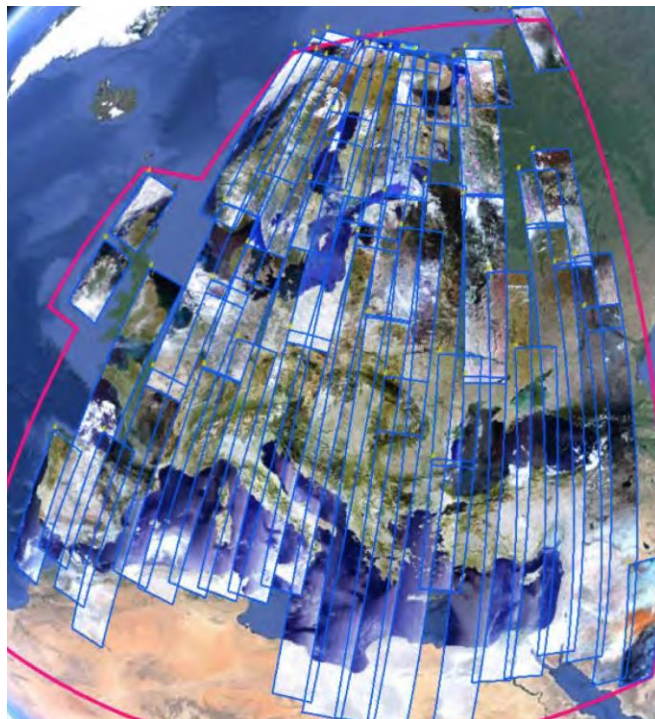| Band/Unit	REQUIREMENTS		S2-MPC RESULTS	
	SNR@Lref	Lref	SNR	Margin
	-	W/m2/Sr/µm	-	%
B01	129	129.0	1016,50	688
B02	154	128.0	201,90	31
B03	168	128.0	228,60	36
B04	142	108.0	214,50	51
B05	117	74.5	238,50	104
B06	89	68.0	206,10	132
B07	105	67.0	208,80	99
B08	174	103.0	208,10	20
B8A	72	52.5	153,10	113
B09	114	9.0	164,70	44

Level-1 Products Pre-Qualification

- ✓ Fix Pattern Noise (FPN) measured using a vicarious method with products over Greenland homogeneous sites
- ✓ Results in line with requirements except for B11 and B12 → the performance will be consolidated with more samples

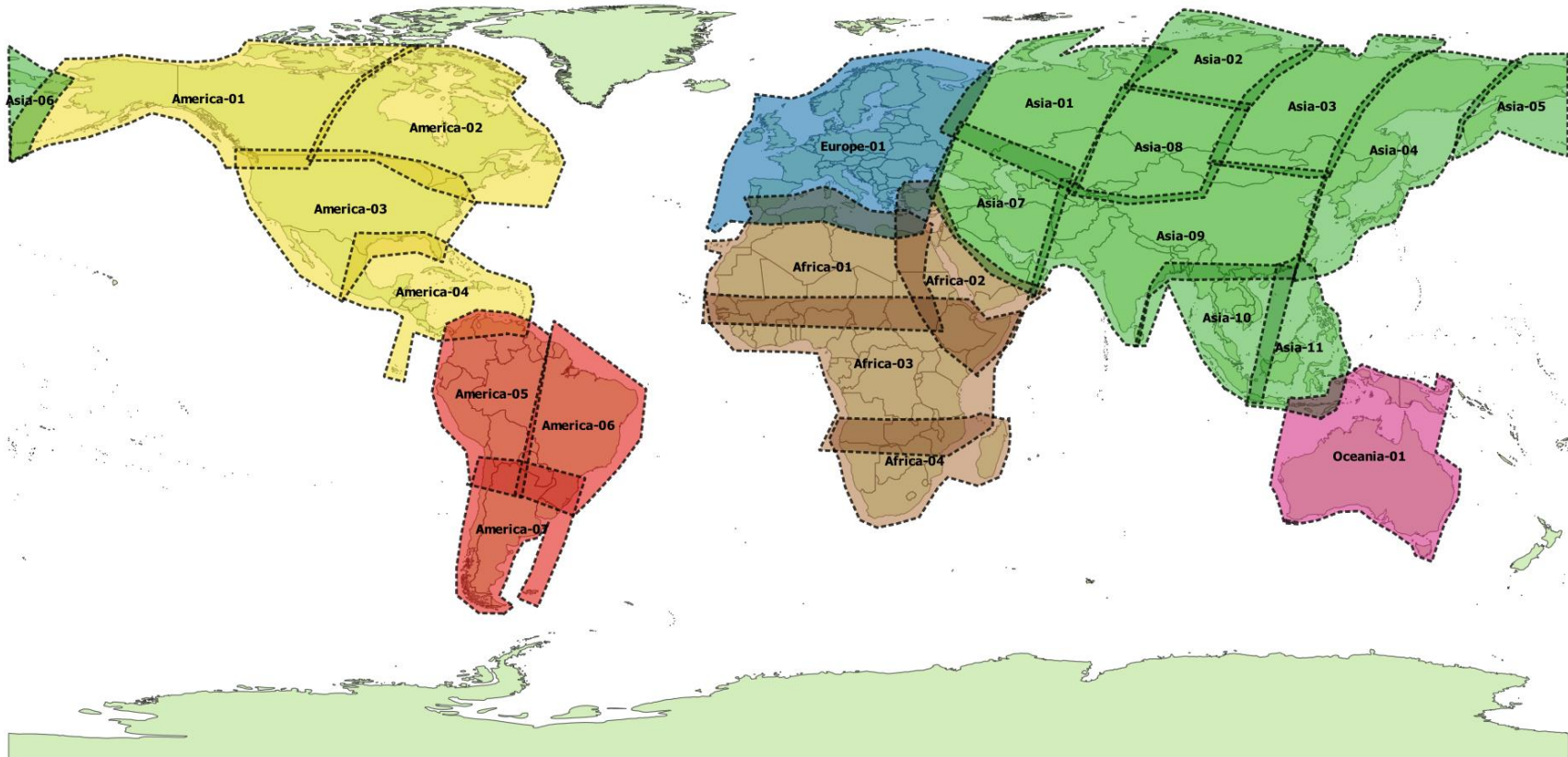| Band/Unit	REQUIREMENTS		MPC RESULTS	
	FPN@Lref W/m2/Sr/µm	Lref W/m2/Sr/µm	FPN W/m2/Sr/µm	Mean radiance W/m2/Sr/µm
B01	0.258	129.0	0.047	230.86
B02	0.256	128.0	0.075	229.01
B03	0.256	128.0	0.073	204.71
B04	0.216	108.0	0.055	174.93
B05	0.149	74.5	0.041	163.85
B06	0.136	68.0	0.046	148.42
B07	0.133	67.0	0.051	131.73
B08	0.206	103.0	0.044	113.78
B8A	0.114	52.5	0.045	105.17
B09	0.027	9.0	0.047	57.62
B11	0.008	4.0	**0.012**	4.45
B12	0.003	1.5	**0.007**	1.85

Global Reference Image (GRI)

- Objective: To obtain a full repeat cycle dataset of well-localized mono-spectral Level-1B images (band 4) which will be used as reference images in the processing chain.

- Methodology: Massive spatio-triangulation on large blocks.
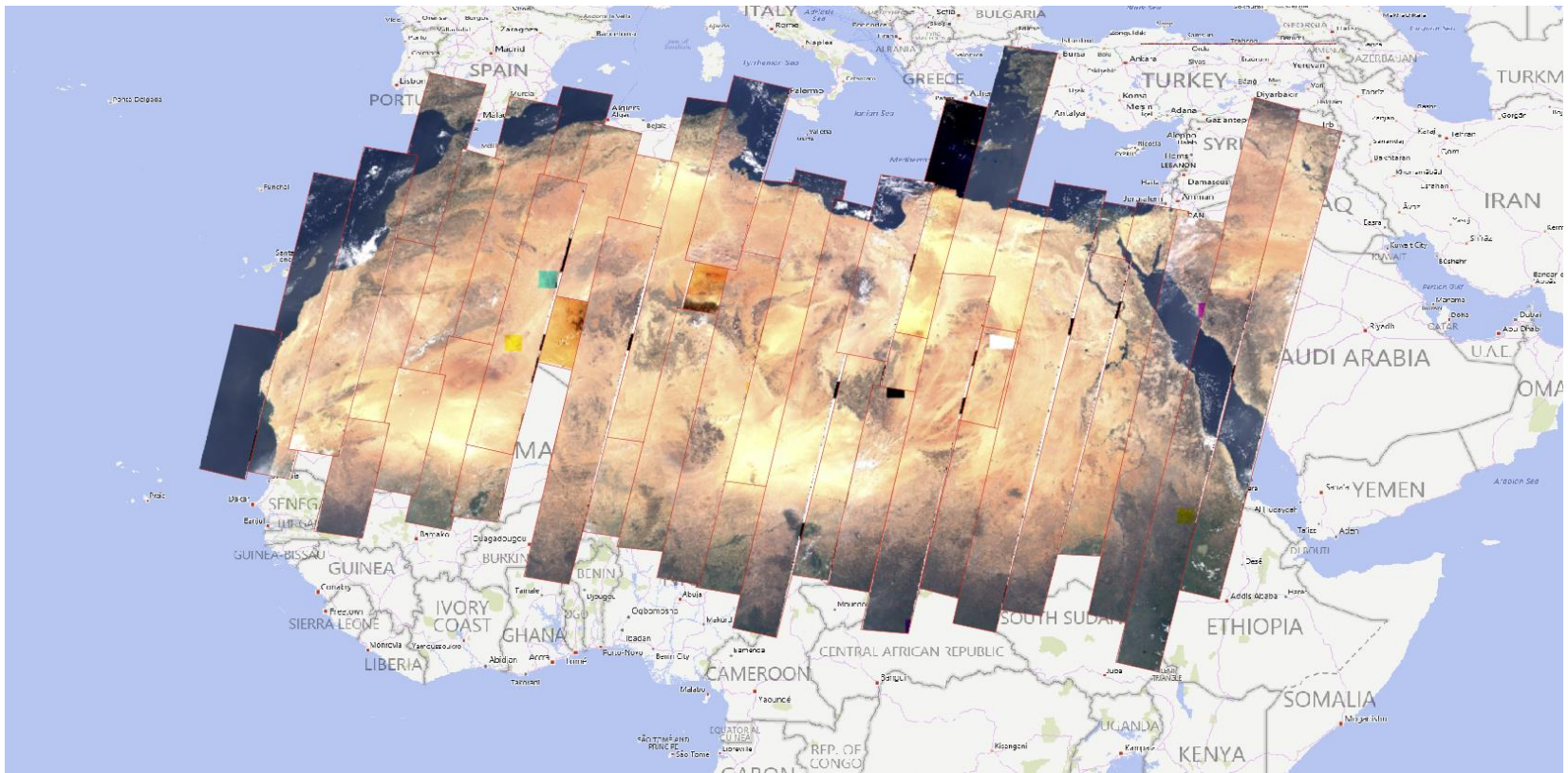
- A set of blocks defined: cf. following slide.

S2 Products → Space Triangulation → S2 Products + refined viewing models

Image and ancillary data → GCP and tie points block adjustment

DEM → GCP and tie points block adjustment

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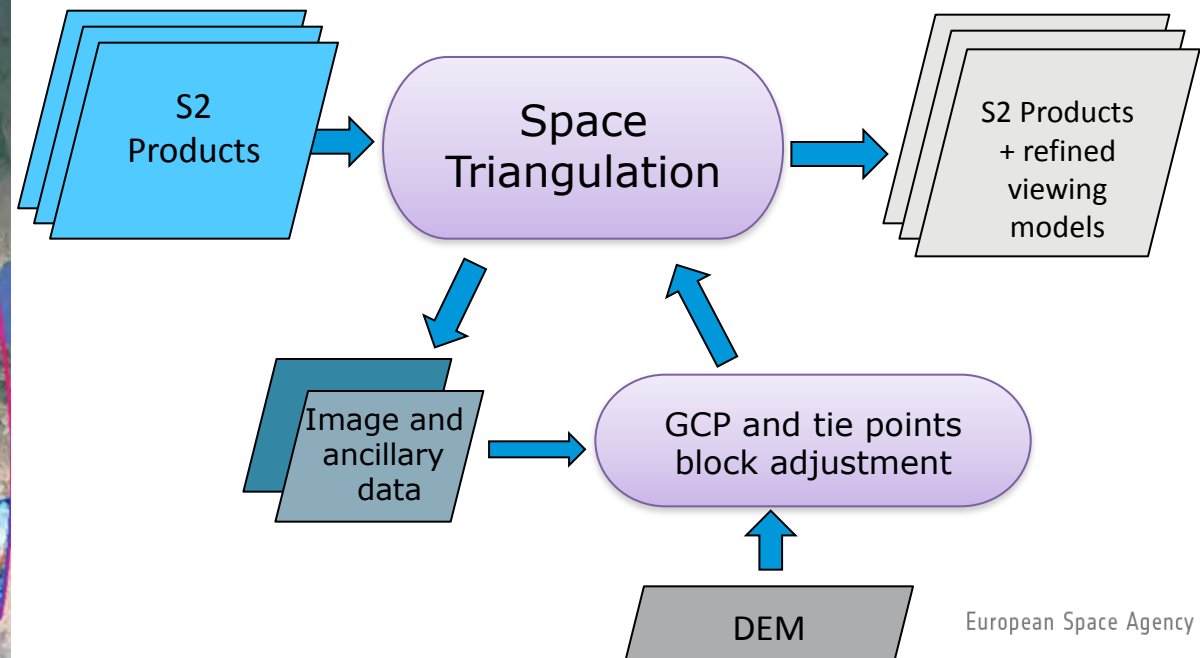
Global Reference Image (GRI)

- GRI sub-blocks

Global Reference Image (GRI)
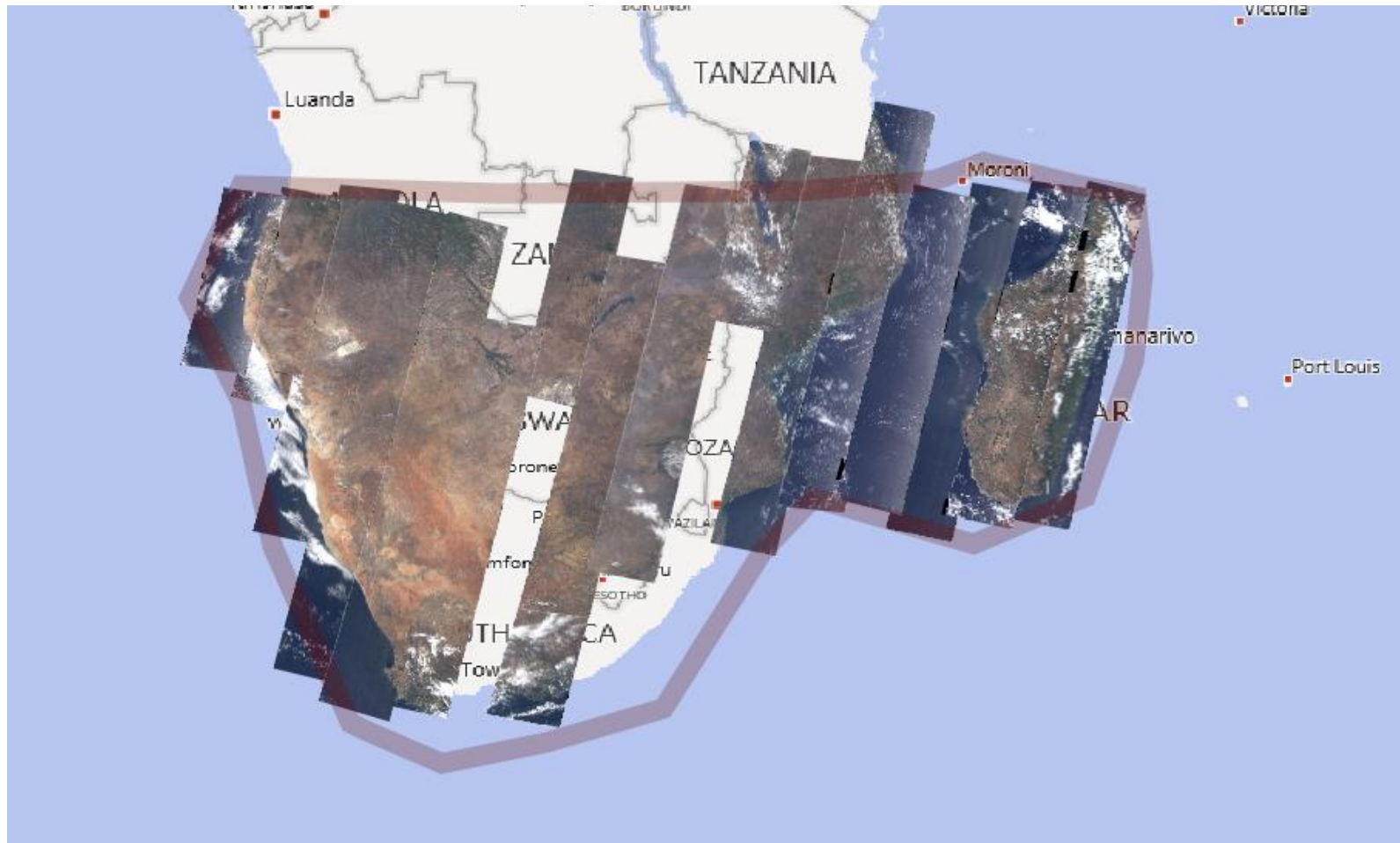

Selection of a set of 48 non-cloudy images on North Africa for GRI Africa-01 sub-block.
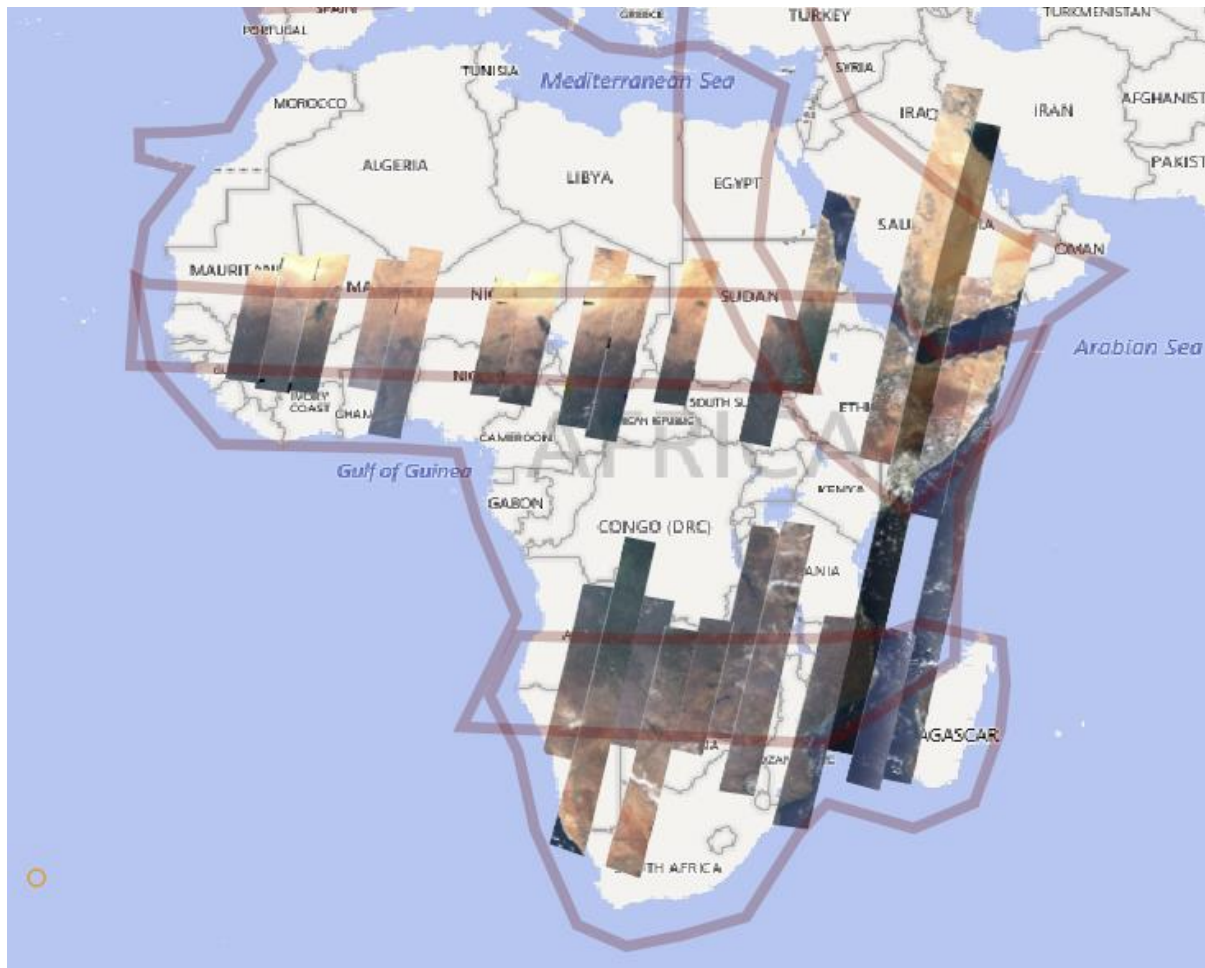
Pre-selection of non-cloudy images for GRI Africa-02 and Africa-03 sub-blocks.

Pre-selection of non-cloudy images for GRI Africa-04 sub-block.

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Global Reference Image (GRI)

- GRI development schedule:
  - ✓ Generation of Europe-01 sub-block
  - o Validation of Europe-01 sub-block on-going
  - o Selection of data for Africa-01 at 95%
  - o Generation of Africa-01 sub-block by February 2016
  - o Selection of data for Africa-02 and Africa-03 at 30%
  - o Selection of data for Africa-04 at 75%
  - o Generation of all of Europe-Africa-Asia region by August 2016
  - o Generation of the World-wide GRI by August 2017

Level-2A / Algorithm Overview
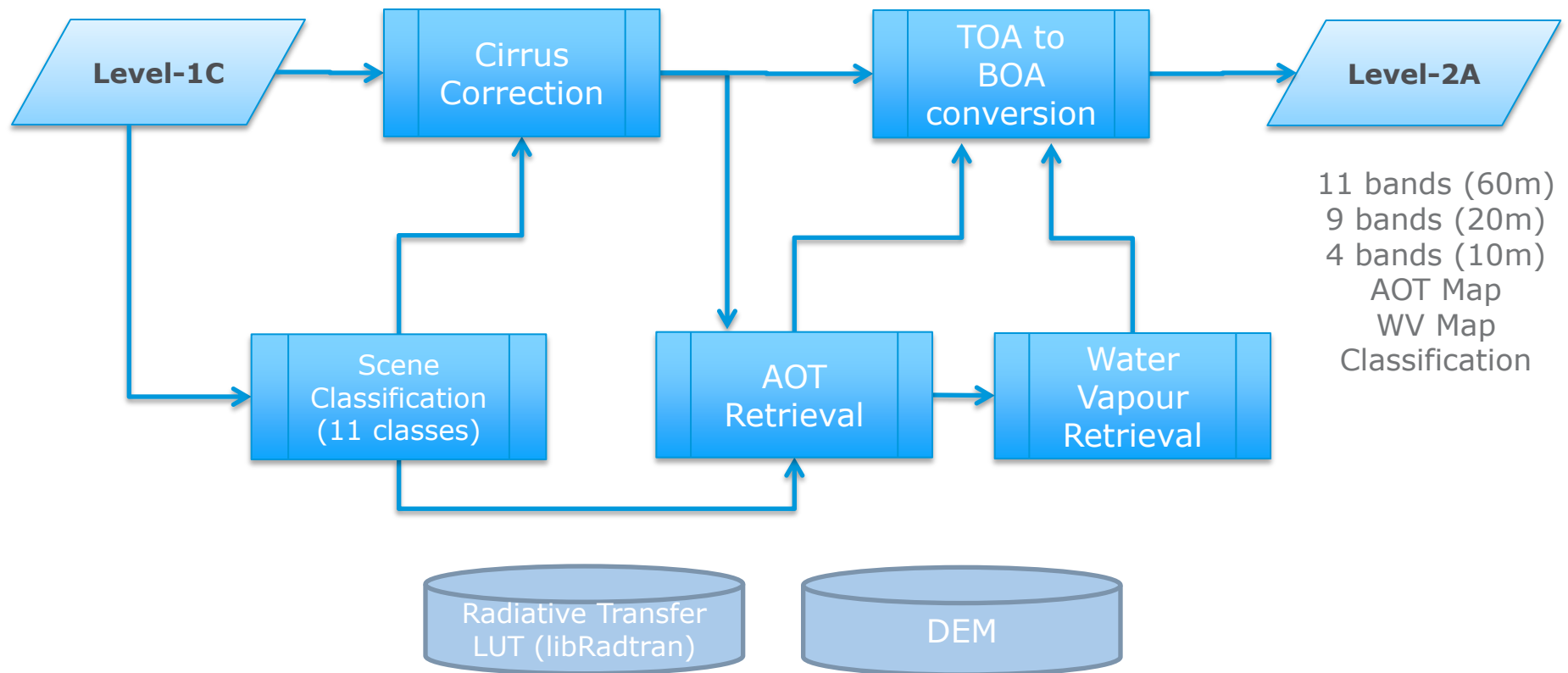
- Level-2A algorithm is implemented in Sen2Cor Processor
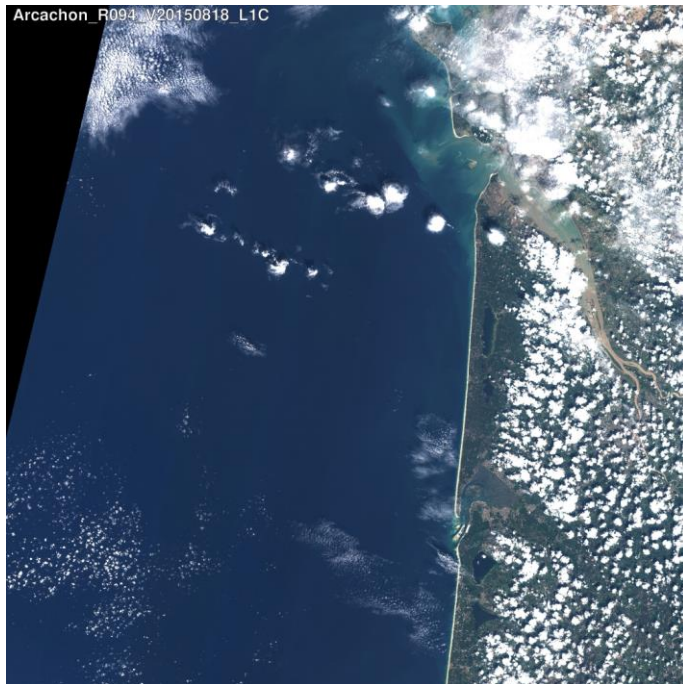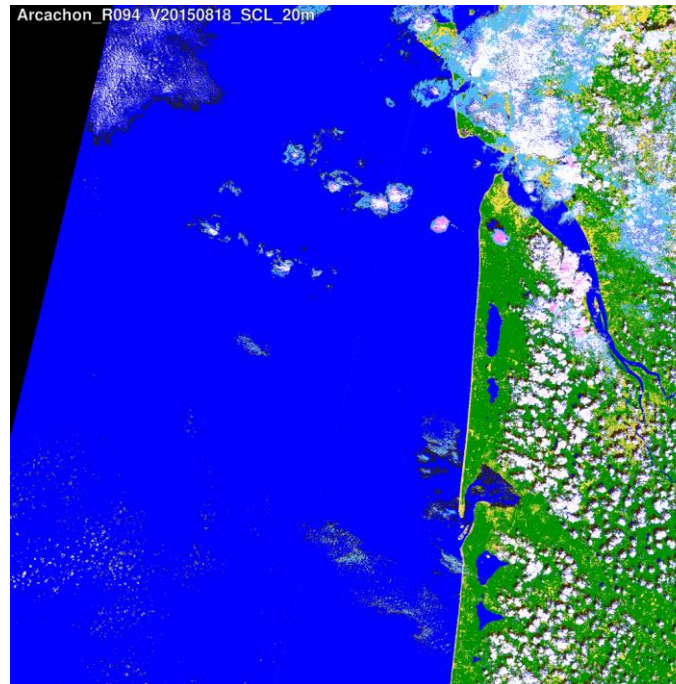- Sen2Cor processor developed with DLR TELESPAZIO

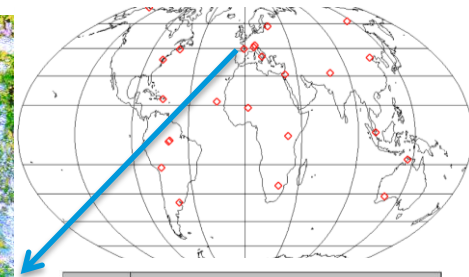# Level-2A Products Qualification Intermediate Results

✓ Scene classification pre-qualified over 20 test sites, with some identified issues:

    ✓ cloud shadows are sometimes classified as water

    ✓ Clouds sometimes classified as snow

    ✓ Turbid waters can be classified as cloud

L1C product (R:B04, G:B03, B:B02)

Scene Classification at 20m

Label	Classification
0	NO_DATA
1	SATURATED_OR_DEFECTIVE
2	DARK_AREA_PIXELS
3	CLOUD_SHADOWS
4	VEGETATION
5	BARE_SOILS
6	WATER
7	CLOUD_LOW_PROBABILITY
8	CLOUD_MEDIUM_PROBABILITY
9	CLOUD_HIGH_PROBABILITY
10	THIN_CIRRUS
11	SNOW

Level-2A Products Qualification Intermediate Results

- ✓ L2A prototype processor successfully pre-qualified on landscapes with vegetation
- ✓ First results shows an overcompensation of cirrus effect on surface reflectance
  - ➔ Algorithm parameterisation needs to be adjusted
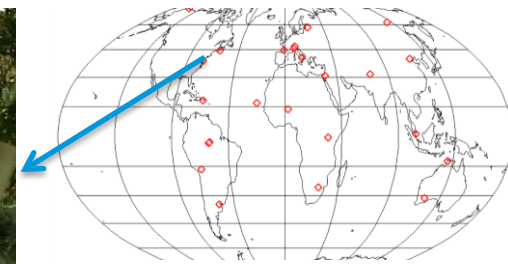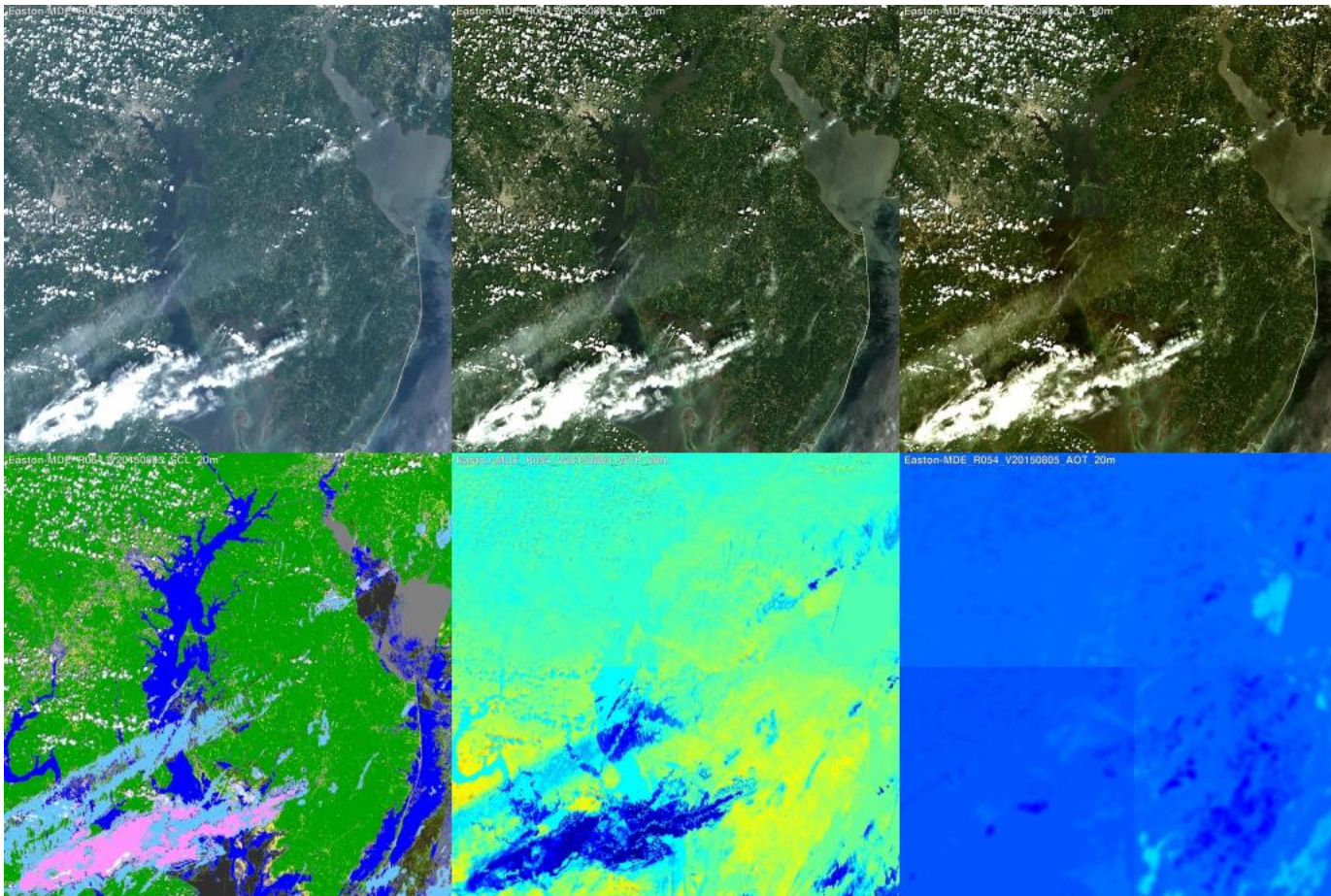
L1C, L2A 20m BOA, L2A 60m BOA (left to right)

Scene Classification, Water Vapour 20m, AOT 20m (left to right)

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On-line Resources

- Technical documents available on sentinels.copernicus.eu website:

    - ✓ Sentinel-2A Spectral Response Functions (Excel file)

    - ✓ Tiling grid (KML file)

    - ✓ Products Specification Document (PDF+XSD)

    - ✓ Data quality report

    - ✓ High-level L1C and L2A algorithm descriptions

MPC (Mission Performance Centre) Team

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Ricardo Moyano (DEIMOS)

Sentinel-2 Cal/Val Activities Status

esa

Thank you very much for your attention!

Further information available at:
http://sentinels.copernicus.eu